before collision. No drop is seen at 5.4 volts which would correspond to the loss of 10.4 volts which is normally assumed to take place at ionization.

From curves of such nature for different velocities of impact, it has been possible to determine more surely than heretofore the energy losses at electron impact. The outstanding results of the investigation are:

1. The discovery by Mohler, Foote and Meggers of a resonance potential involving an energy loss of 6.7 volts was confirmed. The work from which these investigators were able to deduce the existence of this critical potential seemed subject to some very serious difficulties in interpretation. These difficulties have been cleared up. The 6.7 volt type of collision does not occur for electrons with energies less than 8.5 volts, but at voltages above the ionization point it is the most important type of resonating collision.

2. Indications were also found that a collision involving an energy loss of about 5.7 volts also occurs in mercury. This is in agreement with the fact that absorption lines have been found by previous investigators in the mercury spectrum in a region which through the quantum relation corresponds to this potential.

3. Little has been hitherto known about the nature of the ionizing collision. The present method has cast some light on this matter. The results obtained indicate that at such a collision the impinging electron loses all of its energy, and also that the electron which is the product of the ionization leaves the parent atom with negligible energy. This conclusion is at variance with the usual conception of the ionization process.

THE CRYSTAL STRUCTURE OF BERYLLIUM AND OF BERYLLIUM OXIDE

By L. W. McKeehan

Research Laboratories of the American Telephone and Telegraph Company
and the Western Electric Company, Incorporated

The structure of the lighter elements and of their compounds should, on account of their greater simplicity, be of especial value in deciding what rôle the so-called valence electrons play in connecting atoms. Beryllium (Be; atomic number 4) is the lightest metal the crystal structure of which has not hitherto been determined by X-ray methods. Its accepted atomic weight is $w = 9.10$, although a recent determination,[1] apparently of high accuracy, gives $w = 9.018$ which is in much better agreement with the

evidence indicating that the element consists of a single atomic species.[2]

Through the kindness of one of my colleagues, Dr. H. E. Ives, a small supply of metallic beryllium, recently prepared for him in this laboratory by Mr. G. O. Smith, was made available to me for this study. The method of preparation was by the electrolysis of $2BeF_2.NaF$ with from 7 to 15 amperes at 80 volts. This is a modification of the method of Fichter and Jablczynski[3] who used a lower voltage. The product of the process is a fine gray powder interspersed with thin flakes up to half a millimeter in greatest dimensions, which show good metallic lustre. The principal impurity to be expected is beryllium oxide (BeO), and this should not exceed in amount a few per cent by weight.

A thin-walled pyrex glass tube about one millimeter in diameter was packed loosely with the beryllium powder, the looseness of packing being intended to reduce the chance of anisotropy.[4] This sample was not thick enough to cast a very sharply defined shadow on the film, a circumstance which somewhat reduces the accuracy of the results.[5] A water-cooled molybdenum target, bombarded by about 30 milliamperes of electrons at about 30,000 volts, and provided with ZrO_2 filters[6] gave an intense source of X-rays, the photographically important wave-lengths being[7] 0.71212×10^{-8} cm. (K α_2) and 0.70783×10^{-8} cm. (K α_1). The radius of the photographic film was 20.36 cm. The time of exposure was about 18 hours. In taking the first photograph the cylindrical sample was kept stationary; in taking the second photograph the sample was rotated about its axis through a small angle at intervals of one hour. The two photographs were quite similar in general appearance, but the second had smoother lines in its pattern, so that it alone was used in the final measurements and calculations.

In order to eliminate from consideration any lines certainly due to the presence of BeO a sample of that substance in the form of a fine powder was examined in the same way. The results are presented in Table I, and show that the diffracting centers lie at the points of two symmetrically interpenetrating hexagonal space lattices, each with the axial ratio $c/a = 1.63$ and with $a = 2.696 \times 10^{-8}$ cm. There are three faint lines which must be attributed to the presence of impurities. Assuming that one molecule, BeO, is associated with each lattice point and taking[8] $N = 6.0594 \times 10^{23}$, $w = 9.018$, this gives a computed density 2.99 gm./cm³. Both structure and density are in agreement with published values,[9] although a recent paper by Gerlach[10] contains a very different result. A careful examination of his data, however, shows that the resolving power of his apparatus was not high, and that all the lines which he reported as intense are within a short distance of positions accountable for by the structure here proposed.

Comparing the pattern obtained for Be with that obtained for BeO it was found that the first three lines in the former and possibly also the fourth were attributable to the oxide and its principal impurity. A brief search by graphical methods[11] showed that the fundamental space lattice was hexagonal, and that the fourth line of pattern might be retained. A more exact analysis gives the results presented in Table II, and shows that the diffracting points form two symmetrically interpenetrating hexagonal lattices, each with the axial ratio $c/a = 1.58$ and with $a = 2.283 \times 10^{-8}$ cm. No lines are left unaccounted for this structure, which is consistent with the hexagonal structure ($c/a = 1.5802$) determined by optical methods.[12] Assuming that one atom is associated with each lattice point, and taking N and w as given above, this gives a computed density 1.827 gm./cm^{3}., or about one per cent less than the best previous values.[13] The relative positions of the two component space lattices along the hexagonal axis are not determined with any accuracy, the intensities being very roughly estimated and not particularly significant.

Comparing the proposed structure for Be with those already reported for elements in the same column of the periodic table, it is clear that it belongs rather with Mg, Zn, and Cd than with Ca, Sr, and Ba, the first three being hexagonal, all with c/a greater than 1.58 and increasing with the atomic

TABLE I—Be

ESTIMATED INTENSITY	MEASURED 2rΘ IN CM.	COMPUTED LOG ($10^8 d$)	ATTRIBUTED TO[1]	COMPUTED[2] LOG ($10^8 a$)
2	4.69	0.4911	X^3	
6	6.60	0.3437	BeO	
1	6.97	0.3201	BeO	
4	7.44	0.2921	(10.0)	0.3546
2	8.05	0.2583	(00.2)	0.3607
10	8.37	0.2416	(10.1)	0.3611
2	11.02	0.1244	(10.2)	0.3587
4	12.89	0.0583	(11.0)	0.3593
2	14.44	0.0108	(10.3)	0.3576
4			(20.0)	
4			(11.2)	
2	15.55	$\bar{1}.9801$	(20.1)	0.3593
5			(00.4)	
5			(20.2)	
1	18.33	.9128	(10.4)	0.3572
			Mean	0.3586
			Result $a =$	2.283×10^{-8} cm.

[1] All planes theoretically capable of reflection within the range of the tabulated values of 2rΘ are included.

[2] Computed for $c/a = 1.58$.

[3] X = impurity in BeO.

[4] Diffuse band not resolved. The theoretical range in 2rΘ is only 0.58 cm.

[5] Not observed with certainty.

number, whereas Ca, the only member of the second three which has been analyzed, has cubic symmetry.[14]　The remaining element in this column, Hg, has rhombohedral symmetry.[15]

The oxide, BeO, finds an analog in ZnO, all the other monoxides in the column having cubic symmetry,[16] except HgO which forms monoclinic crystals.[17]　The structure of ZnO has been reported by W. L. Bragg[18] to be hexagonal close-packing of molecules with $c/a = 1.608$ and $a = 3.22 \times 10^{-8}$ cm.　Recent data obtained by Hedvall[19] but not reduced by him is in good agreement with this structure.　Bragg regards the two hexagonal lattices of the proposed arrangement as determining the positions of the zinc atom-centers, and suggests that the oxygen atom-centers lie at the points of two similar lattices derived from these by displacing both of them along the hexagonal axis by about $3c/8$.　The same type of structure is at

TABLE II—BeO

ESTIMATED INTENSITY	MEASURED $2r\Theta$ IN CM.	COMPUTED LOG $(10^8 d)$	ATTRIBUTED TO[1]	COMPUTED[2] LOG $(10^8 a)$
2	4.69	0.4911	Y[3]	
1	5.43	0.4277	X	
8	6.23	0.3685	(10.0)	0.4310
6	6.67	0.3392	(00.2)	0.4301
10	7.09	0.3128	(10.1)	0.4297
1	7.57	0.2847	X	
3	9.15	0.2035	(10.2)	0.4311
8	10.90	0.1290	(11.0)	0.4300
8	11.89	0.0923	(10.3)	0.4308
	4		(20.0)	
6	12.86	0.0593	(11.2)	0.4303
	4		(20.1)	
	4		(00.4)	
	4		(20.2)	
	4		(10.4)	
2	16.40	$\bar{1}.9582$	(20.3)	0.4293
1	16.90	$\bar{1}.9459$	(21.0)	0.4309
1	17.29	$\bar{1}.9366$	(21.1)	0.4303
	4		(11.4)	
	5		(10.5)	
2	18.34	$\bar{1}.9126$	(21.2)	0.4304
	4		(20.4)	
1	19.35	$\bar{1}.8911$	(30.0)	0.4305
2	20.04	$\bar{1}.8770$	(21.3)	0.4298
			Mean	0.43032
			Result $a =$	2.696×10^{-8} cm.

[1] All planes theoretically capable of reflection within the range of the tabulated values of $2r\Theta$ are included.

[2] Computed for $c/a = 1.63$.

[3] X = impurity.

[4] Not observed with certainty.

[5] Forms with next an irresolvable doublet ($\Delta s = 0.01$ cm.).

least consistent with the data for BeO. In both cases there should be different properties in the two directions of the hexagonal axis.

The fact that c/a is greater for Zn than for Be, but less for ZnO than BeO is hard to explain unless we assume a considerable rearrangement of electrons to take place during the formation of one of the oxides. It is interesting to note that another substance which possesses this structure is ice,[20] which tempts one to regard frozen water as an oxide of the formula $(OH_4)O$, the radical OH_4 being divalent, just as NH_4 is univalent and CH_4 is saturated.

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SOME CASES OF NERVE-DEAFNESS AND THEIR BEARING ON RESONANCE THEORIES OF AUDITION

By John P. Minton*

Ryerson Physical Laboratory, University of Chicago

1. *Introduction.*—The present paper deals with certain cases of nerve-deafness and their bearing on the mechanical resonance theories of tone perception. The paper is thus a continuation of a recent one published in the February issue, 1922, of the *Physical Review* and like the earlier